DIFFERENTIAL CATALOGUE OF RIGHT ASCENSIONS OF 102 STARS OF THE TASHKENT WIDE ZENITH ZONE

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ABSTRACT. The author presents a differential catalogue of the right ascensions of 102 stars ranging in declination from 25° to 53°. His data are referred to the FK4 system. The observations were carried out at the Tashkent Astronomical Observatory with the Askania Works No. 85951 transit instrument, which has an objective 100 mm in diameter, a focal length of 1000 mm, a magnification of 100, and a horizontal axis 650 mm in length.

The stars were divided into hour groupings and observed visually by the group method, since 122 reference stars, 48 equatorial stars, and 12 northern stars were included in the program in addition to the 102 program stars. A sighting mark 80.3 m north of the transit pavilion was used to check on the instrument's azimuth. Transit data was recorded by a writing chronograph. A quartz clock was used as a time reference check. Data from 117 nights from October 1964 to June 1966 were used in the final reduction. On the average each program star was observed 19 times. The mean square error of a single determination of the right ascension of a catalogue star was $\pm 0^{s}.023$ for the zenith zone.

A comparison of the author's catalogue with FK4 by means of the GC reveals a systematic error as large as $0^{s}.01$, which he explains as being due to an accumulation of accidental errors and the inaccuracy of the catalogues. He considers his catalog to be of comparable accuracy to the GC.

The author also determined the corrections to the right ascensions of the 12 northern stars in his program and gives a differential catalogue for them based on the FK4 system. He also investigated the effect on the right ascensions determined for the program stars of using a combination of observations of northern and zenith stars to determine the instrument's azimuth rather than equatorial and zenith stars. He found that the system of right ascensions of the program stars was the same in both cases, so only the catalogue based on the latter combination is given.

In connection with the developing problem of detailed study of the non- /67
uniformity of the earth's rotation, significant difficulties have arisen regarding the accuracy of right ascensions of stars of the fundamental catalogue. Therefore the results of observations of Service Time are used for improving the fundamental reference system [1-3], for which a program of observations including, in particular, observations of northern stars at both culminations was set up. The list of stars compiled by B. V. Yasevich [4] was used as the basis of the program.

Included in the program were 285 stars which were distributed in declination in the following way: 122 reference zenith stars ($+25° < \delta < +52°$), 102 program stars ($+25° < \delta < +53°$), 48 equatorial stars ($-17° < \delta < +15°$), 12 northern stars ($+75° < \delta < +80°$), and the pole star for determining the absolute azimuth. The northern stars were observed at both culminations.

To improve the right ascensions it was necessary to solve two problems: the differential determinations of the right ascensions of 102 stars on the FK4 system and the derivation of the absolute catalogue of right ascensions of zenith stars. Only the solution of the first of these is discussed in the present article.

The instrument and its survey. The observations were carried out with the Askaniya Works No. 85951 transit instrument. A detailed description of a similar instrument is given in the paper [5]. The basic characteristics of the instrument are the following: the diameter of the objective is 100 mm, the focal distance is 1000 mm, the length of the horizontal axis is 650 mm, and the magnification is 100^{X}. It was mounted in a wooden pavilion in 1932. The internal dimensions of the pavilion are: 2.9 m along the meridian, 4.2 m in the vertical direction, and the height of the floor is 2.2 m. The pavilion is slid open forming a slit with a width of 1.5 m. At a distance of 80.3 m to the north from it is situated a sighting mark, protected by a frame stall. The lens for the sighting mark is situated within the pavilion on a masonry pier at a distance of 2.34 m from the instrument.

In 1962, the author, along with T. Nuraliyev, investigated the suspended level by the method of A. S. Vasil'yev [6] with the Herbst testing machine. The quality of the grinding of the vial appeared to be satisfactory. A value

of a division of $\tau = 1\overset{s}{.}146$ was obtained; it agrees well with the value of $\tau = 1\overset{s}{.}14$ found by V. T. Beda in 1957. The temperature coefficient of the level was not determined, but since the investigations, which were carried out at various times at various temperatures, gave the same results, one can assume that it is small. /68

They obtained a value of a revolution of the micrometer screw from observations of near-polar stars; it is equal to $R = 6\overset{s}{.}845 \pm 0\overset{s}{.}010$. The backlash of the micrometer screw was determined three times by aiming the moving bisector at the fixed filament [5]; it was found to be very small, smaller than the accidental errors of the determination, and was taken equal to zero. The width of the micrometer's contact K was found in August 1963 and 1964 with the aid of a telephone [5]. It was found to be equal to $K = 0\overset{s}{.}056$. In February 1966 they investigated the width of the micrometer's contact with the aid of a telephone and also on the basis of star observations [5]. In the first case, they obtained a value of $0\overset{s}{.}030$, but from the observations of 22 stars they obtained $K = 0\overset{s}{.}032$. Therefore from January 1966 the time corrections obtained were calculated with a new value of the contact width equal to $K = 0\overset{s}{.}031$.

In the interval between investigations the time corrections were calculated taking into account interpolated values of the contact width. The pivots of the transit instrument were investigated in December 1963 by the contact method with the help of Uverskiy's interferometer. The calculations were carried out by the method of Moreau-Verbaandert [7]. Investigations showed that although the average deviation of the figure of the pivots from the ideal circle attains 1μ, however for both pivots the depressions and protrusions are symmetrical. Therefore the correction to the inclination for the incorrectness of the figure of the pivots does not exceed $0\overset{s}{.}006$, and $0\overset{s}{.}004$ in the azimuth. Upon reduction of our observations these corrections were not taken into account.

Program of observations. The list of stars was divided into hour groupings. Each group contained from 7-12 near-zenith stars, 4 equatorial stars, and one northern star.

For comparison of the method of A. A. Nemiro [1] with the classical

method of determining the absolute azimuth, the polar star was included in the program. But daytime observations were not obtained because of poor visibility. The choice of groups was carried out in such a way that the total of the azimuthal coefficients of the stars of the zenith zone would be close to zero. The observations were carried out visually by the group method [1]. Each evening they observed the four groups. Before and after the observations they took readings of the sighting mark both for a positive and a negative rotation of the micrometer screw, making ten aimings. The program was made up so that at the start and at the end of each group a pair of equatorial stars were observed necessarily in various orders of observations.

A writing chronograph running on sidereal time was the recording device. A Rhode and Schwartz quartz clock K_1 running on mean solar time served as the operating clock. Before and after the observations of each group, reading of the chronograph and the quartz clock were compared with each other. The variation of the chronograph was taken into account for each group separately, and the instants of transits of stars were referred to the common start of the observations. The observations were carried out from October 1964 to June 1966 (140 nights in all).

For the final reduction and derivation of the right ascension corrections the material of 117 nights or 468 time corrections were used. The observations were carried out with a reversal of the instrument in the middle of the observations of each star and by two revolutions of the micrometer screw; 18 pairs of contacts were recorded. For zenith and equatorial stars, 10 pairs of sym- /69
metrical contacts were selected, and for northern stars from 18 to 21 pairs. Before and after the observation of each star, readings of the level were taken. Prior to the start of the observations, if it was required, the inclination of the instrument was adjusted. In the course of an evening, the inclination always decreased within the limits of 3 to 7 half-divisions of the level.

Metal grids were used to reduce the brightness of the stars. The observations of all stars were distributed equally between the two orders of observations EW and WE. The setting of the tube was always done in zenith distance by a positive rotation of the micrometer screw. On the average they observed each program star 19 times, with 12 being the minimum number of observations and 22

the maximum. The mean square error of a single determination of the right ascension of a catalogue star for the zenith zone is equal to $\pm 0^s.023$.

Reduction of the observations and derivation of the catalogue. The values of the apparent right ascensions of the stars were taken from the tables of the ITA and "Apparent Places of Fundamental Stars" FK4, and for the program stars these values were calculated from the corresponding catalogue [8-12].

The instants of star transits obtained were corrected for the variation in azimuth of the instrument during the course of a given evening; the azimuth was determined from readings of the sighting mark. It was assumed that the variation in the azimuth is proportional to the time [13]. The azimuth of the instrument was calculated from a combination of observations of a group of fundamental stars with each equatorial star from the equation

$$a = \frac{u'_s - u'_z}{A_s - A_z}, \tag{1}$$

where

u'_s is the preliminary time correction found from the observations of the equatorial star without taking into account the azimuth of the instrument;

u'_z is the average correction obtained from the observations of the group of reference stars without taking into account the azimuth; and

A_s and A_z are the azimuthal coefficients of an equatorial star and the average azimuthal coefficient of the group of reference stars.

They obtained a separate value of the instrument's azimuth for each equatorial star; nevertheless they calculated from the four equatorial stars an average value for each group. They found a time correction u_{ref} based on the reference stars for each group. The right ascensions of the program stars were calculated from the equation

$$\alpha_{prog,\, i} = u_{ref} + T_i, \tag{2}$$

where

$$T_i = (t_i + A_i \delta a_i) + B_i\, b + A_i\, a + (m) \sec \delta_i; \tag{3}$$

t_i is the instant of the record of the star's transit;

A_i and B_i are the Mayer coefficients;

a is the instrument's azimuth;

δa_i is the correction for azimuth variation determined from the readings of the sighting mark; and

$(m) \sec \delta_i$ is the correction for the width of the contact, backlash, and diurnal aberration;

$$(m) = \frac{R}{2}(M_x + K) - 0^s.021 \cos \varphi. \tag{4}$$

The corrections of the right ascensions of the program stars were calculated on the system of the corresponding catalogue. In order to exclude error dependent on the order of the observations, they found initially the average value for each order of observations $\Delta\alpha_{EW}$, $\Delta\alpha_{WE}$, and then took their arithmetical mean: /70

$$\Delta\alpha = \frac{\Delta\alpha_{EW} + \Delta\alpha_{EW}}{2}. \tag{5}$$

They found the error in the determination of the right ascension of each star from the equation

$$\varepsilon_\alpha = \pm \frac{1}{2} \sqrt{\bar{\varepsilon}_1^2 + \bar{\varepsilon}_2^2}; \tag{6}$$

here

$$\bar{\varepsilon}_1 = \pm \sqrt{\frac{\sum v_{EW}^2}{n_1 (n_1 - 1)}}; \quad \bar{\varepsilon}_2 = \pm \sqrt{\frac{\sum v_{WE}^2}{n_2 (n_2 - 1)}};$$

v_{EW} and v_{WE} are the deviations of the corrections to the right ascension from their average value in the case of the orders EW and WE;

n_1 and n_2 are the numbers of observations of each star for the orders EW and WE, respectively.

The errors of the average result of the observations for each star are given in a separate column of the catalogue. On the average, they amount to $\pm 0^s.005$ for a single star.

The square errors of a single observation averaged over time and reduced to the equator were calculated from the equation

$$\varepsilon_\vartheta = \pm \sqrt{\frac{\sum (\varepsilon_1^2 + \varepsilon_2^2)\cos^2 \delta}{k}}, \qquad (7)$$

where

k is the number of program stars in the group;

$$\varepsilon_1 = \pm \sqrt{\frac{\sum v_{EW}^2}{n_1 - 1}}; \quad \varepsilon_2 = \pm \sqrt{\frac{\sum v_{WE}^2}{n_2 - 1}}.$$

On the average, the square error of a single observation reduced to the equator is $\pm 0^s.024$.

Comparison of the catalogue obtained with other catalogues.

All the stars of our catalogue (Appendix 1) are in the GC. It has 78 stars in common with KGZ, 44 with N30, 59 with $FK4_{supp}$, 79 with the differential catalogue of E. V. Suvorova (Suv), and 34 with ITA catalogue [14]. We compared our catalogue with the catalogues listed and with FK4 by means of the GC, KGZ, and N30. For this, they compared the FK4 catalogue with GC, KGZ and N30 based on the reference stars. They averaged the differences in right ascensions over five-degree zones in declination. The systematic differences obtained for all the catalogues are presented in Table 1[1] (n is the number of common stars).

It is evident from the table that upon comparison of our catalogue with FK4 by means of the GC the systematic error reaches $0^s.01$, and by means of KGZ and N30, $0^s.02$. It is most probable that these differences are explained by an accumulation of accidental errors and the inaccuracy

1. In all tables the values of quantities are given in $0^s.001$.

of the catalogues, and that the accuracy of our catalogue is comparable with the accuracy of the KGZ and GC.

A comparison of the catalogue presented with others with respect to /71
$\Delta\alpha_\alpha$ is presented after the exclusion of $\Delta\alpha_\delta$ from the differences in the right ascensions. Smoothed [13,15] systematic differences of the type $\Delta\alpha_\alpha$ are given in Table 2.

TABLE 1

δ	C - GC		FK4 - GC		C - KGZ		FK4-KGZ		C - N30	
	Δα	n	Δα	n	Δα	n	Δα	n	Δα	n
25—30	—29	5	—19	8	—10	4	— 6	8	+ 4	3
30—35	—23	16	—19	20	+ 3	13	— 6	20	+23	7
35—40	— 1	28	—16	22	+ 3	20	—10	21	— 1	13
40—45	—20	22	—17	29	—12	17	— 7	28	—25	11
45—50	—26	23	—20	38	—14	17	— 8	38	—33	4
50—55	—13	8	—20	5	+ 9	7	—10	8	— 8	6

δ	FK4 - N30		Comparison of the catalogue with FK4 through			C-FK4 supp		C - Suv	
	Δα	n	KGC	GC	N30	Δα	n	Δα	n
25—30	— 2	8	— 4	—10	+ 6	+23	3	— 9	2
30—35	— 4	20	+ 9	— 4	+27	+25	11	+ 4	15
35—40	—13	22	+13	+15	+12	— 9	3	—10	20
40—45	—15	29	— 5	— 3	—10	—21	15	—11	18
45—50	—12	38	— 6	— 6	—21	—24	11	— 5	18
50—55	—24	5	+19	+ 7	+16	+ 8	6	—10	6

TABLE 2

α	Comparison with FK4 through			C-FK4 supp	C - Suv
	GC	N30	KGZ		
0—3	— 3	— 7	—5	+10	+ 3
3—6	— 3	—20	—5	— 9	+ 1
6—9	+ 5	0	—3	— 1	— 6
9—12	— 3	+10	—2	— 2	— 9
12—15	+ 5	+ 7	+7	+10	— 9
15—18	+ 6	+13	—9	+ 2	— 1
18—21	—14	— 3	—5	— 7	+ 1
21—24	+ 2	—13	+2	—14	+21

TABLE 3

m	Catalogue minus				
	GC	KGC	N30	FK4 supp	Suv
0—4	—	—	—	—	—
4—5	—4	—5	—6	+4	+2
5—6	—2	—3	—1	0	0
6—7	+6	+4	+6	—1	+2

The errors which depend on the brightness of the stars were determined in the following manner. Initially, the systematic differences of the form $\Delta\alpha_\delta$ and then the averages for each hour $\Delta\alpha_\alpha$ were excluded from the differences in right ascensions "our catalogue minus a comparable one" for the common stars; the remaining differences were grouped according to stellar magnitudes; the systematic differences of the form $\Delta\alpha_m$ are indicated in Table 3.

Determination of the corrections of the right ascensions of northern stars. Since the Kyustner series were not observed by us, we calculated the corrections to the right ascensions of northern stars for the control of systematic errors of the type $\Delta\alpha_\delta$. Using the observational material, we determined the right ascensions of 12 northern stars with declination 75° to 80° and α Ursae Minoris. In this case the fine corrections were determined from /72 zenith stars and the azimuth from equatorial stars. The calculations were carried out the same as indicated above.

Each northern star was observed an average of 43 times; the minimum number of observations was 32, and the maximum number was 47. The corrections in right ascensions were determined separately for the upper and lower culminations. In order to exclude errors dependent on the order of the observations, the average corrections to the right ascensions were initially calculated for each order of the observations and then the simple average was taken. The final corrections to the right ascensions of the northern stars were determined as the arithmetic averages of the corrections in right ascensions obtained from the upper and lower culminations:

$$\Delta\alpha = \frac{\Delta\alpha_{up} + \Delta\alpha_{low}}{2}. \qquad (8)$$

The accuracy was estimated in the same way as for the zenith stars. The differential catalogue of northern stars obtained on the FK4 system is given in Appendix 2. The catalogue of northern stars was compared with FK4 and N30. The comparison of our catalogue with the catalogues indicated above with respect to $\Delta\alpha_\delta$ is given below (n is the number of common stars):

Catalogue differences	$\Delta\alpha_\delta$	n
C - FK4	- 81	12
C - N30	-105	12
FK4 - N30	- 24	12

It follows from this that upon the calculation of the azimuth from equatorial stars the right ascensions of northern stars are determined with significant systematic errors. We present the systematic differences, arranged by threes, of the type $\Delta\alpha_\delta$ obtained from a comparison of our catalogue with others:

α	C —FK4	C —N30	FK4—N30
0—3	— 8	0	+ 8
3—6	+21	+ 7	—14
6—9	+18	—15	—32
9—12	+17	—11	—28
12—15	+10	—16	—26
15—18	—12	+16	+29
18—21	—24	+17	+42
21—24	—20	+32	+52

Effect of a chance of the azimuthal stars on the right ascensions of the program stars. The question of the choice of stars for the determination of the time corrections is discussed in a series of papers [16-20]. M. S. Zverev [16], investigating the choice of reference stars for the relative determination of right ascensions, constructed graphs of the Aurell type and established the fact that upon a decrease in the systematic errors in both the instrumental and the personal nature of the observation it is necessary to work with narrow zones in declination. In this case the weights of the right ascensions practically reach the maximum value (0.8). M. S. Zverev recommends, for the best determination of azimuth, combinations of observations of upper and lower culminations of stars with declinations from +70° to +80°.

One can observe equatorial or northern stars as "azimuthal" stars to obtain the right ascensions of stars. Equatorial stars have the following advantages over northern stars: more exact right ascensions, small accidental error upon recording a transit across the meridian, and a large speed of /73
transit across the meridian.

We found the azimuth from the combination of observations of equatorial and zenith stars, and observations of northern stars were initially not investigated. Therefore it was necessary to find out how the systematic errors of the differential catalogue are changed if the azimuth is determined from a combination of observations of northern and zenith stars. The average correction based on a group of reference zenith stars was calculated from the equation

$$u^{S}_{ref} = u'_z - A_z a_S. \tag{9}$$

If the azimuth was found from northern stars, then

$$u^{N}_{ref} = u'_z - A_z a_N. \tag{10}$$

where

u'_z is the time correction based on the reference stars without taking into account the azimuth of the instrument;

A_z is the average azimuthal coefficient of the group of reference zenith stars; and

a_S and a_N are the azimuth of the instrument calculated from northern and southern stars.

Subtracting (9) from (10), we obtain

$$u^{N}_{ref} - u^{S}_{ref} = A_z(a_S - a_N). \tag{11}$$

The right ascensions of the program stars were calculated from the equation

$$\alpha_{prog} = T + u^{S}_{ref} + A_{prog} a_S. \tag{12}$$

Then one can obtain for the case where the azimuth is determined from northern stars:

$$\alpha_{prog} = T + u^{N}_{ref} + A_{prog} a_N, \tag{13}$$

where

T is the instant of transit of the star across the meridian corrected for the inclination, contact width, backlash, diurnal aberration, and the variation in azimuth found from readings of the sighting mark.

From (11) to (13) we obtain

$$\Delta\alpha_N = \Delta\alpha_S + [A_{prog}(a_N - a_S) - A_z(a_N - a_S)]. \tag{14}$$

The difference $a_N - a_S$ based on opposite culminations are given in Table 4. Since like culminations of northern stars take place as a rule in two hours, and the reduction was carried out for hour groups, the averages (given in parentheses) were calculated from the adjacent values $a_N - a_S$.

The systematic nature of the culmination difference is evident from the table. This is confirmed by the observations of A. Kadyrov [21], who obtained for northern stars at upper culminations

$$a_N - a_S = -0^s.034.$$

Evidently, this systematic difference does not depend on the instrument nor on the observer, and it seems to us that it is explained by the systematic errors in the right ascensions of northern stars or the effect of local conditions. The effect of $a_N - a_S$ on the right ascension of the program stars is shown in Table 5 [the values $\Delta\alpha_\delta$ were calculated from Eq. (14)], from which it is evident that the northern "azimuthal" stars are observed only in one culmination, and the system of right ascension of the program stars /74 differs with respect to $\Delta\alpha_\delta$ from the system obtained when locating the azimuth from equatorial stars. In the case of the observation of northern stars at both culminations, these systems practically coincide.

TABLE 4

Group	$a_N - a_S$			A_m
	Upper culm.	Lower culm.	Average	
1	(−35)	+16	−10	+ 36
2	−45	(+39)	− 3	− 65
3	(−30)	+62	+16	+ 23
4	(−30)	+30	0	− 12
5	−15	(+24)	+ 4	− 50
6	(−24)	+18	− 3	+ 31
7	−33	(+19)	− 7	+ 3
8	(−14)	+20	+ 3	− 47
9	+ 6	(+26)	+16	−112
10	(+ 4)	+33	+18	+ 51
11	+ 3	(+28)	+16	+ 44
12	(− 6)	+23	+ 8	− 30
13	−16	(+14)	− 1	− 78
14	(−21)	+ 4	− 8	+ 5
15	−26	(+20)	− 3	−110
16	−50	(+20)	−15	+ 53
17	(−26)	+35	+ 4	− 51
18	− 2	(+38)	+18	− 9
19	(−20)	+42	+11	+ 51
20	−39	(+18)	−10	− 46
21	(−54)	− 6	−30	+ 28
22	−68	(+18)	−25	+ 48
23	(−46)	+41	− 2	+ 72
24	−25	(+28)	+ 2	+ 42
Average	−26	+25	0	− 5

Thus a second version of the differential catalogue of right ascensions was obtained. It was compared with the catalogues GC, KGZ, and also with FK4 through the catalogues GC and KGZ. The systematic difference of the type $\Delta\alpha_\delta$, obtained upon comparison of our catalogue with FK4 through GC and

TABLE 5

δ	$\Delta\alpha_\delta = \Delta\alpha_N - \Delta\alpha_S$		
	Upper culm.	Lower culm.	Average
25—30	— 3	+7	+2
30—35	— 3	+5	+1
35—40	— 2	+2	0
40—45	+ 1	0	0
45—50	+ 4	—5	0
50—55	+11	—9	+1

KGZ, respectively, is presented in Tables 6 and 7.

And so, upon the determination of the azimuth and the combination of observations of zenith and northern stars, significant systematic errors arise which are excluded upon the observation of northern stars at both culminations. Then the system of right ascensions of the program stars is found to be the same as for the calculation of the azimuth from a combination of zenith and equatorial stars. Therefore the first version of our catalogue is published (the azimuth was determined from zenith and equatorial stars). /75

Derivation of right ascensions of equatorial stars. If the azimuth is found from a combination of observations of zenith and northern stars, then one can find the right ascensions of the equatorial stars. Since the equatorial stars enter into FK4, the corrections to them permit a control of the system of our instrument. Initially, the azimuth was calculated from equatorial and zenith stars. The corrections to the right ascensions of equatorial stars were obtained from the equation

$$\Delta\alpha_S = u^S_{ref} - u_{prog(s)} + A_{prog(s)}a_s, \qquad (15)$$

where

u^S_{ref} is the time correction based on zenith stars;

$u_{prog(s)}$ is the time correction based on an equatorial star without taking into account the instrument's azimuth; and

$A_{prog(s)}$ is the azimuthal coefficient of an equatorial star.

The average for both orders of observation were obtained to exclude errors dependent on the order of observation, $\Delta\alpha_s$. The final corrections to the right ascensions of the equatorial stars were calculated from Eq. (14). On the average, each equatorial star was observed 23 times; the minimum number of observations was 19 and the maximum number was 27. The estimate of

TABLE 6

δ	n	Azimuth according to equatorial stars		Azimuth according to northern stars						FK4 - GC
				Upper culm.		Lower culm.		Average		
		C-GC	C-FK4	C-GC	C-FK4	C-GC	C-FK4	C-GC	C-FK4	
25–30	5	–29	–10	–31	–12	–22	– 3	–26	– 8	-19
30–35	16	–23	– 4	–26	– 7	–17	+ 2	–21	– 2	-19
35–40	28	– 1	+15	– 3	+13	+ 1	+17	– 1	+15	-16
40–45	22	–20	– 3	–19	– 2	–21	– 4	–20	– 3	-17
45–50	23	–26	– 6	–22	– 2	–31	–11	–26	– 6	-20
50–55	8	–13	+ 7	– 2	+18	–22	– 2	–12	+ 8	-20

TABLE 7

δ	n	Azimuth according to equatorial stars		Azimuth according to northern stars						FK4 - KGC
				Upper culm.		Lower culm.		Average		
		C-KGZ	C-FK4	C-KGZ	C-FK4	C-KGZ	C-FK4	C-KGZ	C-FK4	
25–30	4	–10	– 4	–12	– 6	0	+ 6	– 6	0	-6
30–35	13	+ 3	+ 9	0	+ 6	+ 9	+15	+ 4	+10	-6
35–40	20	+ 3	+13	+ 1	+11	+ 5	+15	+ 3	+13	-10
40–45	17	–12	– 5	–11	– 4	–12	– 5	–12	– 5	-7
45–50	17	–14	– 6	– 9	– 1	–19	–11	–14	– 6	-8
50–55	7	+ 9	+19	+21	+31	+ 1	+11	+11	+21	-10

accuracy was made the same way as for the zenith stars. The mean square error of a determination of the right ascension of a single star is $\pm 0^s.004$. /76

The differential catalogue of right ascensions obtained for 48 equatorial stars is given in Appendix 3. It was compared with the FK4 and N30 catalogues. The systematic difference of the type $\Delta\alpha_\delta$ (n is the number of stars) and the smoothed systematic difference of the type $\Delta\alpha_\alpha$ are presented in Tables 8 and 9. The catalogues obtained for near-equa-

TABLE 8

δ		C - FK4			C-N30	FK4-N30	n
		Upper culm.	Lower culm.	Average			
−15	−20	−47	− 4	−26	−37	−11	3
−10	−15	−19	+22	+ 2	−10	−11	3
− 5	−10	−22	+19	− 2	−16	−14	10
0	− 5	−18	+21	+ 2	− 8	−10	12
0	+ 5	−18	+ 9	− 5	−15	−10	8
+ 5	+10	−11	+17	+ 3	− 6	− 9	11
+10	+15	+ 3	+22	+12	+ 5	− 7	1

torial stars agrees well with respect to $\Delta\alpha_\delta$ (Table 8) with the FK4 system (with the exclusion of the stars farthest from the equator). The systematic difference with the N30 catalogue of the type $\Delta\alpha_\delta$ reaches a large value.

TABLE 9

α	C - FK4			C - N30	FK4 - N30
	Upper culm.	Lower culm.	Average		
0— 3	− 7	+3	−2	+1	+3
3— 6	+ 5	+7	+4	+6	0
6— 9	+10	+3	+6	+4	−2
9—12	+11	+2	+6	+4	−3
12—15	+ 4	0	+2	0	−1
15—18	− 1	0	−2	−1	0
18—21	− 6	−1	−4	−2	+2
21—24	− 6	+2	−3	+2	+4

This is explained by the fact that with respect to $\Delta\alpha_\delta$ the N30 system differs from the FK4 system for the equatorial zone. It is evident from Table 9 that our catalogue differs little with respect to $\Delta\alpha_\alpha$ from the FK4 and N30 catalogues, which indicates a sufficient reliability in the determination of the right ascensions.

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APPENDIX 1

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Catalogue number				m	δ_{1960}	$\alpha_{1960.0}$	E_r 1960+	ε_α	n	C - KGC	C - GC	C - N30	C-$FK4_{supp}$	C - Suv	C - ITA
KGZ	GC	N 30	$FK4_{supp}$												
40	488	74	2022	5.7	+52° 50′	$00^h\ 22^m 55^s.892$	4.95	±4	19	+24	+11	+23	+31	+20	+30
43	546	—	2027	5.2	44 10	26 04.197	4.94	4	20	− 9	−41	—	+39	+32	+38
49	611	—	—	6.1	33 22	29 17.816	4.93	6	21	+62	+63	—	—	+26	—
74	812	138	2043	5.4	39 14	38 56.592	4.94	6	20	+ 9	+ 1	− 4	+ 5	+ 9	—
158	1541	263	—	6.6	39 16	01 14 59.309	5.01	5	19	−11	−16	−18	—	—	—
181	1850	311	2100	6.3	34 36	29 50.272	5.01	5	20	+19	+26	+33	+38	+ 5	—
197	2025	341	—	4.9	40 23	38 12.530	5.00	6	20	−19	−25	−34	—	−50	−19
284	2813	—	—	5.6	49 58	02 18 18.527	5.11	5	20	+ 3	−21	—	—	− 5	—
290	2902	—	2165	4.9	50 06	22 56.568	5.09	4	22	+31	+18	—	+11	+12	+11
305	3103	—	—	5.6	34 31	33 20.695	5.10	6	21	−14	+ 4	—	—	+ 4	—
—	3161	—	—	6.3	37 55	35 58.443	5.16	7	16	—	+81	—	—	—	—
333	3356	572	—	4.6	29 05	35 31.282	5.09	4	21	− 3	−12	−21	—	—	+ 6
384	3791	—	—	4.8	39 28	03 08 41.924	5.27	6	22	−16	−18	—	—	− 2	—
397	3923	—	—	5.4	43 53	15 05.301	5.31	6	20	27	−48	-	—	−14	—
440	4287	—	—	4.3	48 04	33 38.162	5.29	6	21	−67	−63	—	—	−37	−48
449	4387	—	—	5.6	37 27	38 31.186	5.31	5	20	− 8	−37	—	—	—	—
576	5359	—	2325	5.3	31 21	04 23 33.240	5.47	4	22	− 6	−38	—	+ 8	+30	—
606	5609	—	2338	4.5	41 11	33 54.765	5.45	5	22	+ 3	+27	—	− 7	− 4	—
643	5932	—	—	5.6	42 31	49 57.892	5.47	6	22	−33	−63	—	—	−11	—
661	6064	1060	—	5.0	37 50	56 32.229	5.49	6	21	+ 3	−12	−38	—	—	—
692	6311	1106	—	5.6	46 55	05 07 43.933	5.50	5	18	+ 6	−15	−49	—	+27	+20
719	6556	1145	2400	6.1	41 46	18 58.309	5.49	5	21	−37	−46	−50	−28	−33	—
—	6922	—	2417	6.0	47 41	32 14.514	5.51	6	20	—	− 6	—	−47	0	—
—	7066	1216	2425	6.0	31 20	38 00.487	5.49	4	21	—	−126	−27	−18	−11	—
857	7888	—	2470	6.0	32 42	06 09 42.865	5.55	6	19	−53	−124	—	+47	− 5	—
—	8082	1359	—	6.6	35 16	16 13.215	5.55	4	20	—	−48	− 4	—	− 2	—
—	8411	—	2496	6.0	46 43	27 03.715	5.55	6	20	—	−60	—	−22	− 2	—
—	8474	—	2500	5.6–6.2	32 29	29 50.567	5.55	6	20	—	−48	—	− 8	+ 6	—
931	8751	—	2517	5.2	44 34	40 10.372	5.55	5	20	−26	−44	—	−19	−20	−19
953	8931	1485	2527	5.0	41 50	47 56.316	5.55	5	20	−30	−46	−23	0	—	—
984	9405	1556	2549	6.5	33 54	07 05 35.943	5.53	4	18	+23	− 4	+14	+26	+ 9	—
1010	9769	—	2567	5.6	45 18	18 23.950	5.51	3	19	−25	−50	—	−25	−29	−25

APPENDIX 1 (Cont.)

KGC	Catalogue number			m	δ_{1960}	$\alpha_{1960.0}$	E_r 1960+	ε_α	n	C - KGC	C - GC	C - N30	C-$FK4_{supp}$	C - Suv	C - ITA
	GC	N 30	$FK4_{supp}$												
1052	10257	1723	2592	4.9	34 41	35 33.431	5.51	5	19	−28	−44	+ 5	+20	− 8	—
1064	10377	—	2599	5.3	50 32	41 02.780	5.51	5	19	− 8	−17	—	+ 5	−23	—
—	10579	—	—	6.0	33 20	48 28.243	5.51	5	19	—	−44	—	—	—	—
1116	11163	—	2641	5.6	29 47	08 10 40.308	5.49	5	17	− 6	−44	—	+28	− 2	+27
—	11534	—	2660	6.3	45 47	24 49.812	5.49	5	18	—	+ 8	—	− 3	−27	—
1170	12037	2040	2690	6.1	30 51	42 54.419	5.47	6	18	− 3	−22	+53	+66	+ 2	—
1180	12221	2079	2700	5.2	43 53	49 16.175	5.49	6	17	− 4	− 46	−40	−15	−16	−15
—	12341	—	2706	5.9	40 21	53 55.076	5.47	4	18	—	−12	—	−61	−29	—
1233	12799	2206	2738	5.7	46 59	09 14 50.676	5.47	6	17	−28	−47	−30	− 9	−12	− 9
1248	13051	—	2751	5.6	45 47	26 03.172	5.47	4	17	−11	+11	—	−40	−11	—
1271	13265	—	2765	5.7	31 21	34 20.711	5.47	5	17	−11	−39	—	0	−17	0
1283	13372	2314	2773	5.5	39 56	39 32.022	5.48	4	16	+11	0	− 7	+15	−14	+15
1323	13985	2425	2817	6.1	37 36	10 08 50.907	5.56	5	15	+38	+26	+33	+55	+ 8	—
—	14154	—	2827	6.2	48 36	16 58.183	5.58	4	14	—	−67	—	−50	—	—
—	14377	—	2838	6.5	45 25	26 12.336	5.62	9	13	—	+ 1	—	−51	—	−51
1384	14897	2559	2863	6.1	28 11	47 42.026	5.54	5	16	−22	−35	+16	+20	−16	—
1391	14974	2565	2870	4.8	43 24	51 41.039	5.54	5	16	−12	−16	−46	−21	—	−20
1440	15625	—	2908	5.1	43 42	11 20 38.212	5.62	4	17	−26	−43	—	−24	−36	−24
—	15857	—	2923	6.3	37 02	31 48.883	5.62	6	17	—	−14	—	−40	−51	—
1484	16199	—	—	5.8	35 09	47 37.170	5.62	4	17	−14	−25	—	—	−61	—
1534	16906	2862	2994	5.0	51 47	12 22 05.219	5.60	6	18	+16	− 1	− 3	+14	—	+14
1538	16964	2879	2999	4.6	28 29	24 56.724	5.60	7	18	− 7	−13	+16	+21	—	—
—	17231	—	3013	6.3	36 10	37 20.264	5.60	5	18	—	−39	—	−14	+ 7	—
1579	17430	—	—	5.9	37 44	48 16.764	5.60	3	18	+56	+ 48	—	—	−20	+68
1640	18171	—	—	5.9	46 14	13 24 33.710	5.68	6	18	+ 3	+ 1	—	—	− 7	—
—	18283	3086	—	6.2	42 19	29 31.660	5.68	5	18	—	−40	−12	—	—	—
1661	18421	3107	—	4.9	36 30	35 40.595	5.68	3	17	− 3	−28	+13	—	−23	—
1676	18636	3138	3094	5.6	38 45	45 16.215	5.61	5	18	− 6	−29	− 4	+13	—	—
1730	19345	3253	3136	6.3	30 37	14 18 23.661	5.71	4	21	+26	+19	+20	+25	+11	—
1738	19519	3279	3144	6.2	36 22	26 37.013	5.68	4	20	+24	+ 6	+38	+50	—	—
1750	19668	3305	3155	5.9	49 33	33 15.606	5.64	6	19	−38	−46	−27	−12	−36	−12
1763	19841	3330	3166	5.8	40 38	42 11.267	5.67	6	21	−16	−45	+ 2	+15	−15	+14
1811	20380	3418	3197	5.8	50 12	15 07 03.218	5.69	7	18	−37	−51	−22	− 6	−51	− 7
—	20651	—	—	5.9	44 35	19 18.734	5.67	6	20	—	+47	—	—	+14	—
1938	21800	—	—	5.7	36 32	16 10 20.179	5.70	4	21	− 3	−10	—	—	−10	—
1967	22108	—	3296	5.5	37 29	23 58.540	5.70	4	21	+17	+14	—	−14	+13	—
1972	22172	3690	3303	5.0	41 58	27 19.581	5.70	5	21	+ 6	− 2	+10	− 3	− 8	—
1983	22251	—	—	5.6	45 41	30 34.800	5.70	7	21	−13	−62	—	—	—	—
—	23229	—	—	6.0	49 47	17 10 38.886	5.70	4	21	—	−21	—	—	− 5	—
2061	23374	3855	—	4.8	37 20	16 17.351	5.69	6	19	−23	−37	+ 6	—	+17	+20
2073	23544	3878	—	4.5	37 11	22 18.013	5.71	3	20	−29	−31	− 2	—	−14	−19

APPENDIX 1 (Cont.) /80

Catalogue number															
KGC	GC	N 30	$FK4_{supp}$	m	δ_{1960}	$\alpha_{1960.0}$	E_r 1960+	ε_α	n	C - KGC	C - GC	C - N30	C-$FK4_{supp}$	C - Suv	C - ITA
2107	23879	3920	3397	5.8	30°49′	$17^h35^m05^s.307$	5.69	4	18	+ 6	− 6	+60	+68	+36	—
—	24067	—	3408	6.6	44 06	41 54.254	5.69	4	20	—	−29	—	−44	—	—
2187	24787	—	—	5.9	36 27	18 08 35.367	5.70	6	20	+ 3	− 2	—	—	—	—
—	24874	—	3451	5.9	38 46	11 44.637	5.70	5	18	—	+29	—	−93	−131	−92
2203	25085	4081	3458	5.1	49 05	20 31.120	5.70	6	18	−11	−34	−25	−17	—	—
2210	25137	4089	3463	5.0	39 29	22 54.616	5.70	6	18	−11	−18	− 6	+ 3	− 5	—
2221	25340	—	—	5.4	30 31	31 18.093	5.70	4	18	+14	+ 9	—	—	−11	—
2244	25643	—	—	5.5	31 53	42 21.317	5.70	4	18	+12	+12	—	—	−12	—
—	25757	4171	—	5.8	52 57	45 49.364	5.66	8	16	—	−78	−18	—	—	−16
2296	26181	—	—	5.1	46 53	19 00 18.398	5.71	8	17	+26	+20	—	—	+ 2	—
—	26690	—	3545	6.3	35 07	19 05.346	5.64	4	17	—	−13	—	−41	0	—
2383	27249	—	3575	5.0	45 26	39 36.066	5.64	7	17	−21	−69	—	+ 9	+ 1	+ 9
—	27401	—	—	5.7	25 17	46 02.500	5.64	4	17	—	−40	—	—	—	—
2409	27492	4391	3584	5.6	40 30	49 14.846	5.64	5	17	− 1	+ 6	−30	−40	− 3	—
2434	27724	4423	3599	5.2	36 56	58 27.073	5.64	4	17	+ 3	− 1	−14	− 4	+14	—
2513	28642	—	—	5.6	46 33	20 32 36.147	5.65	5	18	+ 4	− 8	—	—	−16	− 4
2553	29036	—	—	4.9	45 58	47 34.384	5.65	7	18	−42	−53	—	—	—	—
2563	29150	4626	—	4.7	44 14	51 49.747	5.65	5	18	+13	−10	+ 2	—	+ 7	+ 8
2629	30013	—	—	5.5	46 32	21 23 31.353	5.47	5	17	−27	−40	—	—	+60	−34
2664	30391	4786	3733	5.3	51 00	40 40.235	5.47	6	19	−15	−34	+12	+11	−23	+11
2758	31252	—	—	4.6	46 20	22 19 22.139	5.32	6	20	+ 4	−10	—	—	+ 3	− 9
—	31824	—	—	6.0	37 12	46 20.839	5.33	5	21	—	+85	—	—	—	—
2818	31896	—	—	5.2	43 06	50 13.510	5.33	6	19	+11	+ 1	—	—	+41	—
2838	32039	5058	3838	6.4	52 26	57 25.967	5.34	7	21	+54	+45	−42	− 4	+ 8	− 5
2864	32288	5098	3857	5.8	43 20	23 08 35.839	5.16	5	20	+ 6	+11	−28	−24	−54	−25
2879	32432	—	—	5.0	48 48	15 52.969	5.18	7	21	− 2	−12	—	—	+ 5	—
2903	3 703	—	—	5.3	39 01	29 19.136	5.16	7	22	+11	+ 6	—	—	+61	− 1
—	33063	—	3914	5.9	36 12	47 39.871	5.14	6	21	—	+48	—	−57	+ 6	—
—	33211	—	3923	6.0	42 26	55 01.431	5.18	7	22	—	+18	—	−76	− 3	—

NOTE 1. ε_α - the mean square error of the right ascensions of stars; n - number of observations.

2. Star 25757 was incorrectly determined as a program star.

CATALOGUE OF NORTHERN STARS

Number FK4	m	δ_{1960}	$\alpha_{1960.0}$	Er 1960+	ε_α	n	C−FK4	C−N 30
41	5.7	+79° 28′	01h08m44.s560	5.34	±30	46	— 51	— 68
Nb	2.1	89 05	55 41.331	5.42	303	45	−1.515	−1.554
173	6.0	75 52	04 43 25.019	5.56	19	41	— 89	−130
260	4.8	77 02	06 54 15.784	5.64	22	43	−105	−152
310	5.7	75 53	08 14 34.162	5.57	20	40	+ 22	— 42
395	5.0	75 55	10 31 44.754	5.39	29	36	— 60	−132
454	5.1	77 50	12 10 20.805	5.36	28	47	— 71	−101
550	2.2	74 19	14 50 47.813	5.44	22	47	−110	−138
590	4.3	77 55	15 45 26.449	5.49	27	48	−101	−147
675	5.0	76 58	17 51 14.135	5.66	25	45	— 26	— 78
734	6.0	79 31	19 24 08.134	5.50	34	32	−126	— 34
795	5.9	77 58	21 06 19.663	5.46	33	43	−158	−113
893	3.4	77 24	23 37 41.012	5.34	34	37	— 96	−122

APPENDIX 3

CATALOGUE OF EQUATORIAL STARS

FK 4	m	δ_{1960}	$\alpha_{1960.0}$	Er 1960+	ε_α	n	C−FK 4	C−N 30
1002	4.7	−05° 56′	00h03m17.s231	5.02	±4	26	— 3	+10
1022	4.9	−01 22	50 57.711	4.94	4	26	— 6	−15
36	4.4	+07 41	01 00 51.824	4.96	5	23	+ 2	— 9
1019	5.3	−03 53	40 42.034	5.06	3	24	0	0
60	4.5	+08 57	43 16.683	5.04	4	27	— 3	— 9
104	4.0	−09 03	02 54 28.305	5.20	4	25	+14	+ 4
107	2.8	+03 56	03 00 11.119	5.18	3	27	+ 7	— 6
149	3.2	−13 37	56 09.687	5.37	3	27	0	−14
1111	5.2	−01 40	59 30.256	5.39	3	26	— 3	— 19
1140	4.7	+15 21	05 02 16.857	5.50	2	26	+12	+ 5
188	2.9	−05 08	05 52.820	5.48	4	27	— 6	−26
1161	5.2	+00 33	56 46.066	5.52	4	26	−14	−22
230	5.7	+04 10	06 02 51.450	5.50	3	25	— 6	−23
1181	5.8	−08 21	58 28.369	5.54	4	22	+19	−21
271	4.1	−15 34	07 01 56.838	5.57	5	22	−14	−18
304	5.1	−03 34	57 44.214	5.48	4	22	+14	+12
(1097)	4.5	−06 14	08 00 11.066	5.52	3	22	(+2)	—
1235	5.8	−00 20	59 55.364	5.48	5	21	+21	+ 8
347	3.8	+02 29	09 12 17.061	5.42	4	19	−14	−11
378	4.9	+08 14	58 06.034	5.49	3	19	+14	+ 6
1261	4.7	−12 52	10 03 10.514	5.49	6	20	+16	+ 6
1284	5.0	+03 50	58 29.693	5.57	2	20	+ 4	−15
418	4.7	+07 33	11 02 57.127	5.54	2	19	+12	— 7
1311	4.6	+06 50	58 49.362	5.61	3	22	+ 4	— 6
450	5.3	+08 57	12 03 10.178	5.59	3	21	0	−10
484	3.7	+03 37	53 35.022	5.62	3	21	−10	−22
1336	5.9	−03 36	57 35.699	5.59	2	22	— 3	−15
1355	5.2	−08 30	13 39 30.516	5.60	4	19	+ 5	— 8
1357	5.7	−15 59	42 20.029	5.70	3	19	— 9	−36
1393	5.7	00 00	14 55 30.014	5.68	3	25	— 6	−11
1394	4.8—5.9	−08 22	58 49.835	5.66	3	26	−13	−31
1417	4.7	−14 10	15 55 56.694	5.68	4	25	−11	−21
1420	5.6	−08 18	58 37.814	5.68	3	26	−12	−23
633	3.4	+09 26	16 55 46.260	5.69	4	25	+14	+ 4
1445	5.0	−04 10	58 56.862	5.69	3	25	+18	+ 3
673	3.5	−09 46	17 56 49.349	5.70	3	24	— 7	−17
680	3.7	+09 33	18 05 27.080	5.70	3	23	+ 6	+ 6

FK 4	m	δ_{1960}	$\alpha_{1960.0}$	Er 1960+	n_α	n	C − FK 4	C − N 30
717	3.6	−04° 57′	19h04m07s.520	5.67	4	22	+ 8	− 7
1500	5.4	−08 00	10 30.497	5.68	4	21	0	−17
1524	5.6	+07 10	20 02 11.042	5.65	2	23	− 6	−10
756	3.4	−00 56	09 14.441	5.65	3	21	−12	−26
800	4.1	+05 05	21 13 49.432	5.57	2	23	−15	−20
1561	4.3	−17 00	20 01.236	5.56	4	21	−54	− 57
1580	6.4	−04 34	56 49.813	5.42	3	21	− 3	−20
827	3.2	−00 31	22 03 43.752	5.40	3	24	− 6	− 7
1602	4.6	+03 36	23 01 50.401	5.26	3	25	0	− 4
1603	4.7	+09 12	04 59.254	5.24	4	24	+ 2	−10
1630	4.7	−06 14	59 54.491	5.01	4	23	−13	−24

NOTE. Star 1097 is from the KGZ catalogue in the ITA System.